Sheet 2: Fundamental Concepts

2.1 A small sound source emits spherical sound waves with sound power $\overline{W} = 1$ W and frequency 250 Hz. Determine at a radial distance of 1 m:

a) The time averaged sound intensity. [Ans: 7.96x10^{-2} W/m^2]

b) The rms value for the sound pressure. [Ans: 5.72 Pa]

The medium is air at normal pressure and temperature with a speed of sound c = 340 m/s and density ρ_0 = 1,21 kg/m^3.

Hint: At $r \geq \lambda/3$ it can be assumed that we have (locally) plane waves.

2.2 An axial fan has similarities to an airplane propeller. The frequency spectra of axial fans is usually dominated by harmonic frequency components. An axial fan with K blades is mounted in a duct and driven by an electric motor with a rotational speed of N rpm (rotations per minute). A silencer is to be designed and mounted in the duct.

a) At which frequencies should the silencer be effective?

b) Determine the frequency components of importance up to 1000 Hz for the speed N = 1450 rpm and with number of fan blades K = 7.

2.3 Handbooks can provide approximate relationships between machine performance, operational conditions and emitted sound power level. One handbook specifies that the sound power level emitted to the inlet and outlet duct is approximately given by: $\overline{W} = Q\,(\Delta P)^2\, 10^{-8}$ [W],

where Q [m^3/s] is the volume flow,

ΔP [Pa] is the fan pressure head.

The handbook claims that this relationship applies for the complete audible frequency range as long as the fan is working close to the operational point giving maximum efficiency. The accuracy is specified to ± 4 dB.

a) Determine the sound power level emitted to the fan outlet duct.

b) Determine the change in sound power at:

(*i*) A doubling of the fan volume flow. [Ans: 3 dB]

(*ii*) A doubling of the fan pressure head. [Ans: 6 dB]

c) Determine the sound power level in the fan outlet duct if the operational point is Q = 6 m^3/s and ΔP = 10000 Pa. [Ans: 128 dB]

2.4

a) Define sound pressure level.

b) A small sound source emits spherical waves with a frequency of 125 Hz. The time averaged sound power level is 1W. The medium is air at normal pressure and temperature with speed of sound c = 340 m/s and density ρ_0 = 1.21 kg/m^3. Determine the sound pressure level at a distance of 1 m from the source. [Ans: 109 dB]

c) How much will the sound pressure level change if the distance is doubled? [Ans: 6 dB]

2.5 A pure tone sound with a frequency of 230 Hz is measured using a third octave band filter with a center frequency of 250 Hz and an octave band filter with the same center frequency. What will

be the difference in the measured sound pressure level between the two measurements? Frequency components other than the 230 Hz tone can be neglected. Refer to table 2-2 in the course book.

2.6 Measurement of the sound power level, in octave bands, for an electric motor, gave results according to the table. Determine the total sound power level if octave bands outside those given in the table can be neglected. [Ans: 87 dB]

f [Hz]	125	250	500	1 k	2 k	4 k	8 k
L_{pn} [dB]	74	76	80	82	81	78	75

2.7 Measured octave-band sound pressure levels for a wood processing machine are tabulated below

f [Hz]	125	250	500	1 k	2 k	4 k	8 k
L_{pn} [dB]	90	92	90	91	93	91	87

Determine:

a) The total sound pressure level, $L_{p_{tot}}$. [Ans: 99 dB]

b) The rms-value of the total sound pressure. [Ans: 1.85 Pa]

2.8 Sound pressure level measurements on a fan gave octave and third-octave band levels according to the tables below.

octave band:

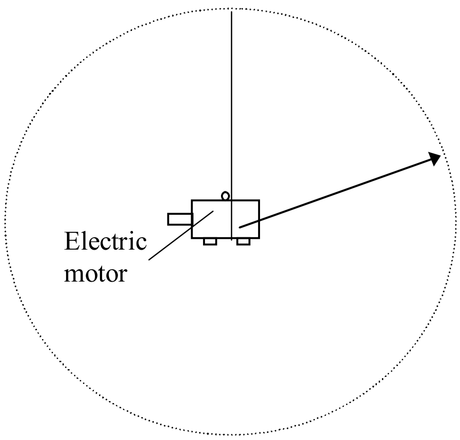
f [Hz]	125	250	500
L_{pn} [dB]	99	91	89

third octave band:

f [Hz]	100	125	160	200	250	315	400	500	630
L_{pn} [dB]	87	88	98	88	83	87	82	85	82

The fan's operating point was constant during the measurements and the measurement accuracy was estimated to be ± 1 dB for each measured frequency band. Investigate whether there is any reason to believe that a mistake has been made.

2.9 In order to measure the sound power level in the 250 Hz octave band emitted by a small electric motor, it was suspended freely in a large room far from any reflecting surfaces. Measurements were then made of the sound pressure level at 5 evenly distributed points on a sphere of radius r = 1.2 m surrounding the motor.



The following sound pressure levels were obtained:

Measurement point	1	2	3	4	5
L_p [dB]	82	82	84	83	84

Determine the sound power level of the motor. The speed of sound and density of air are 343 m/s and 1.21 kg/m^3, respectively. [Ans: 96 dB]

2.10 Some of the third octave bands of a certain sound source are shown in the table below. Other bands are ignored.

i. Copy the table in your sketchbook replacing the (???) with real values showing how you calculate them.

ii. Plot the third octave bands.

Center freq. [Hz]	Lower freq. limit [Hz]	Upper freq. limit [Hz]	L_p [dB]
100	89	???	20
125	???	141	40
160	???	???	50
200	???	???	52
???	224	282	51
315	???	???	45

iii. If we want to calculate the corresponding OCTAVE bands, how many bands will you calculate?

iv. Plot the octave bands on the same figure you used for (b).

v. Calculate the A-weighted sound pressure level for each Octave band using the A-weighting filter shown in the table below.

vi. Calculate the A-weighted overall sound pressure level of this sound source in dBA.

Frequency Band	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz
A-weighting (dB)	-16.1	-8.6	-3.2	0	+1.2